Carbon performance & firm value: The moderating role of CVC & the impact of innovation

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Abstract

This study examines the relationship between corporate carbon performance and firm value. In addition, it also investigates the moderating role of Corporate Venture Capital (CVC) activity and the independent effect of innovation intensity. To investigate the different effects the study used a panel dataset of publicly listed US firms observed between 2014 and 2019.

The results indicate that improvements in carbon performance are associated with a statistically significant decline in firm value over the sample period. This suggests that financial markets may perceive decarbonization efforts of the company as value reducing in the short or medium term. Against the expectations, CVC activity does not mitigate this negative relationship, which implies that CVC investments may not be immediately recognized as value enhancing in the context of carbon performance. In contrast, the innovation intensity shows a positive relationship with firm value, highlighting the importance of innovation as a value driver.

Overall, this study contributes to the sustainable finance literature for US firms by separating the effects of carbon performance, CVC activity and innovation on firm value. The findings indicate a potential trade-off between improvements in carbon performance and market valuation, while innovation serves as a value driver of firm value.

Keywords: Firm value; Tobin´s Q; carbon performance; CVC; innovation; sustainability; ESG

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Abstrato

Este estudo examina a relação entre o desempenho corporativo em termos de carbono e o valor da empresa. Além disso, também investiga o papel moderador da atividade de Capital de Risco Corporativo (CVC) e o efeito independente da intensidade da inovação. Para investigar os diferentes efeitos, o estudo utilizou um conjunto de dados de painel de empresas americanas cotadas em bolsa observadas entre 2014 e 2019.

Os resultados indicam que as melhorias no desempenho em carbono estão associadas a um declínio estatisticamente significativo no valor da empresa durante o período da amostra. Isso sugere que os mercados financeiros podem perceber os esforços de descarbonização da empresa como uma redução de valor a curto ou médio prazo. Contrariamente às expectativas, a atividade de CVC não atenua essa relação negativa, o que implica que os investimentos em CVC podem não ser imediatamente reconhecidos como um aumento de valor no contexto do desempenho em carbono. Em contrapartida, a intensidade da inovação mostra uma relação positiva com o valor da empresa, destacando a importância da inovação como um impulsionador de valor.

No geral, este estudo contribui para a literatura sobre finanças sustentáveis para empresas americanas, separando os efeitos do desempenho em carbono, da atividade de CVC e da inovação no valor da empresa. As conclusões indicam um potencial compromisso entre melhorias no desempenho em carbono e avaliação de mercado, enquanto a inovação serve como um impulsionador do valor da empresa.

Palavras-chave: Valor da empresa; Q de Tobin; desempenho em carbono; CVC; inovação; sustentabilidade; ESG

Título: Desempenho em carbono e valor da empresa: o papel moderador do CVC e o impacto da inovação

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List of Abbreviations

CEO	Chief Executive Officer
CO_2	Carbon Dioxide
CVC	Corporate Venture Capital
DSE	Dhaka Stock Exchange
ESG	Environmental, Social and Governance
FTSE	Financial Times Stock Exchange
GHG	Greenhouse gas
i.e.	id est (in other words)
IPO	Initial Public Offering
IVC	Independent Venture Capital
NRBV	Natural resource-based view
R&D	Research and Development
RBV	Resource based view
S&P	Standard & Poor´s
UK	United Kingdom
US	United States

1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC, 1992), the Kyoto Protocol (1997) and the Paris Agreement (2015) are international agreements that serve as the fundamental basis of global climate policy. For both, national governments and companies, this provides a global framework for dealing with greenhouse gas (GHG) emissions and climate risks. The international agreements not only create a binding framework for policymakers but also increase expectations and pressure on companies to contribute to combating climate change.

The main cause of climate change is the burning of fossil fuels (Ilhan et al., 2021). The increase in GHG, mostly carbon dioxide, leads to global warming, which consequently represents a central cause of climate change (Asyifa & Burhany, 2022; Makan & Kabra, 2021). Greenhouse gas emissions are therefore a central factor, driven primarily by corporate energy production (Dragomir et al., 2023). Companies are major contributors to carbon emissions and are therefore obliged to take environmental responsibility and reduce their carbon footprint (Asyifa & Burhany, 2022). The strategic approach to reduce greenhouse gas emissions is increasingly seen as an integral part of risk management and business strategy (Dragomir et al., 2023). According to this, companies must implement efficient environmental strategies that include clear carbon and energy targets (Makan & Kabra, 2021). Therefore, the success of decarbonization policies depends on the ability of large companies to successfully integrate sustainability goals into their business strategy (Dragomir et al., 2023).

In recent years, climate change and its associated risk have also become increasingly important for institutional investors and other stakeholders. Based on different observations, this leads to a redistribution of corporate values (Matsumura et al., 2014). The increasing requirement for transparency and the growing sensitivity of capital markets to climate-related risks are leading to a trend whereby investors are distancing themselves from companies that do not report their carbon emissions and moving towards companies that successfully control their emissions (Matsumura et al., 2014). Accordingly, carbon performance disclosure has become a relevant driver of firm value (Benkraiem et al., 2022). The disclosure of emissions creates transparency, reduces uncertainty among stakeholders and investors and serves as an indicator of companies strategic adaptability (Zhang et al., 2020).

This implies that recent research increasingly examines how carbon performance, as captured through the disclosure of carbon emissions, affects the firm value. For instance (Bolton &

Kacperczyk, 2025) investigates that carbon disclosure has a strong disciplinary effect on companies to reduce their emissions. According to (Matsumura et al., 2014) capital markets take into account both, corporate emissions and the voluntary disclosure of GHG emissions when valuing firms. The study also investigates that companies who disclose the information have a higher median firm value. The meta-analysis by (Albertini, 2013) further confirms a positive relationship between the disclosure of carbon emissions and firm value, suggesting that stock markets react positively to carbon disclosure as a signal of effective environmental management. These findings indicate that investors are increasingly integrate carbon related information into their valuation decisions. Ceteris Paribus, refusing to disclose emission related information can be very costly for firms and is interpreted by investors as a negative indicator, resulting in lower firm valuation (Matsumura et al., 2014). Going beyond disclosure (Choi & Luo, 2021) examines the direct effect of carbon emission levels and show that higher carbon emissions have a significant negative impact on the firm valuation. Accordingly, companies with low levels of GHG emissions demonstrate a better financial performance over the long-term (Shuwaikh, 2024). Investors therefore rate a higher carbon emission level with a lower corporate performance (Houqe et al., 2022).

The relationship between companies GHG emissions and financial performance is characterized by two opposing theories (Boiral et al., 2012). The win-win approach evaluates firms emission reduction efforts as positive, as they improve competitiveness and a long-term competitive advantage while simultaneously generating environmental and economic benefits. In contrast, the win-lose approach assumes that such efforts primarily incur additional costs which may affect the firms competitiveness and inhibit the main task of maximizing shareholder value (Gallego-Álvarez et al., 2015). In line with the win-win approach (Makan & Kabra, 2021) documents a positive and significant relationship between carbon productivity and financial performance in an emerging market context (in this case India). Furthermore (Gallego-Álvarez et al., 2015) also investigates that proactive environmental strategies represent a competitive organizational capability that is difficult to imitate and goes beyond the control of environmental pollution. Additionally (Saka & Oshika, 2014) found a negative relationship between GHG emissions and market value when examining Japanese listed companies, which creates an incentive to reduce emissions. In summary, these findings highlight that the question of whether and to what extent emission reductions lead to financial benefits remains at the center of a controversial scientific debate in the literature for years.

(Benkraiem et al., 2022) already examines how carbon performance affects firm value and whether this relationship is amplified by gender diversity in leadership and firms' innovation capabilities. Their results indicate that reductions in carbon emissions are associated with a significant positive effect on firm value, particularly when firms exhibit higher levels of management diversity and innovation capacity. Building on the existing findings, this study examines the moderating role of corporate venture capital (CVC) in the relationship between carbon performance and the firm value, while additionally analyzing the independent influence of R&D activities on the value of companies. Investment in CVC operates as a strategic instrument that firms can use, for example to gain access to new technologies, but with a focus on promoting their own businesses (Hegeman & Sørheim, 2021a). In this context, CVC serves as an effective mechanism for outsourcing R&D activities to the external environment, enabling firms to acquire early and valuable insights into novel technologies and to complement internal R&D activities in a targeted manner (Benson & Ziedonis, 2010; Chemmanur & Loutskina, 2014; Dushnitsky & Lenox, 2006). At the same time, CVC engagements may signal capital market participants that firms are strategically focused on innovation and transformation, thereby influencing investors' perceptions of future growth potential.

Despite extensive research on the relationship between carbon performance and firm value, the existing literature provides mixed evidence. While many studies document positive valuation effects of improved carbon performance, which is usually interpreted in terms of the win-win approach, they largely overlook potential short-term trade-offs, where emission reductions are accompanied by a reduction in value. Moreover, research on CVC has primarily focused on its role as a driver of innovation rather than examining its function as a moderating factor in the relationship between carbon performance and firm value. In addition, prior studies frequently analyze innovation merged with other sustainability related activities, making it difficult to evaluate whether R&D expenses represent an independent driver of corporate value, especially during a period in which climate and sustainability aspects have become much more prominent.

By addressing these gaps, the study makes three main contributions to the literature. First, it complements the predominantly positive evidence on the valuation effects of carbon performance by providing empirical support for a potential win-lose scenario in which emission reductions are associated with lower firm value. Secondly, it examines CVC as a moderating factor in the relationship between carbon performance and firm value, rather than a driver of innovation. Thirdly, the thesis contributes to the established literature on innovation and firm value by isolating the effect of R&D expenses and examining their role as an independent driver of corporate value.

This study is structured as follows. Section two presents the existing literature. Section three describes the data and methodology on which the research is based. Section four then discusses the empirical results and analyses them by using robustness checks. The thesis concludes with limitations in section five and the conclusion in section six. The results of the regressions are documented in tables, which can be found in the appendix in section seven.

2. Theoretical framework and literature review

2.1 Carbon Performance

Carbon performance is commonly discussed in the context of environmental performance (Vashisht et al., 2025). Environmental performance represents a construct that includes environmental management variables as well as environmental performance indicators and disclosure variables (Vashisht et al., 2025). Accordingly, the term carbon performance is primarily represented by greenhouse gas emissions, typically measured in tons of CO_2 equivalents (Bolton & Kacperczyk, 2025).

Carbon Performance has become increasingly relevant as it can affect both expected future cash flows and the perceived risk profile of firms in capital markets (Benkraiem et al., 2022). Companies with weaker carbon performance (high emissions) may face rising compliance costs and reputational risks over time (Benkraiem et al., 2022). Conversely, stronger carbon performance (low emissions) may signal operational efficiency and proactive risk management practices (Benkraiem et al., 2022). This indicates that the term carbon performance refers to the reduction of GHG emissions and can be understood as being inversely related to emission intensity, while low emissions represent a positive carbon performance (Benkraiem et al., 2023).

2.2 Carbon performance and firm valuation

In the existing literature, carbon performance is almost always discussed in relation to firms' financial performance. However, the resulting empirical findings over the past decades have found contradictory results regarding the relationship between the two components (Vashisht et al., 2025). Due to the increasing relevance of climate change and the climate-related risks, prior studies have therefore focused on the impact of carbon performance on firm value (Benkraiem et al., 2022; Choi & Luo, 2021; Matsumura et al., 2014).

According to (Russo & Fouts, 1997), the relationship between a company's environmental performance and its financial success can be explained through the Resource-Based View (RBV). This approach is based on the assumption, that a company’s long term success depends on the effective use of its internal resources and capabilities (Madhani, 2010). Consequently, sustainable competitive advantage is understood to be rooted within the company itself, particularly when resources are valuable, rare and difficult to imitate (Russo & Fouts, 1997).

Building on this, the RBV present firms as bundles of heterogeneous resources and capabilities with limited mobility across firms (Gallego-Álvarez et al., 2015). Therefore, the RBV provides an important framework for explaining the causes of achieving a competitive advantage (Kraaijenbrink et al., 2010). By including the natural environment (Hart, 1995) extends the RBV to the natural resource based view (NRBV). While the RBV tends to focus on company-specific resources, the NRBV focuses on the approach of incorporating ecological sustainability, according to which social requirements can lead to the development of unique resources (Shuwaikh et al., 2023). From this perspective, proactive environmental strategies that focus on prevention and go beyond compliance can lead to the creation of firm-specific capabilities and ultimately sustainable competitive advantage (Gallego-Álvarez et al., 2015; Russo & Fouts, 1997). Consistent with the implications of the RBV and NRBV, (Menguc & Ozanne, 2005) examines the influence of resources and capabilities on financial performance, with the results showing that environmental orientation is positively correlated with profit and market share. (Nishitani & Kokubu, 2011) further examines the impact of environmental performance on firm value and shows that investors consider the reduction of greenhouse gas emissions as an intangible value, which in turn increases the value of the company.

This is also supported by the institutional theory perspective, which is based on the fact that companies with higher emissions are under increased pressure due to strict climate regulations (Benkraiem et al., 2022). The institutional theory also serves as a framework and assumes that organizations are influenced by external pressures in their decision-making process. This pressure can come from powerful actors such as the state. In terms of carbon performance, the external pressure is created by imposing certain requirements, such as the regulations on energy consumption or the introduction of the CO_2 tax (Hahn et al., 2015).

The RBV and institutional theory are used to analyze the development of the firms´ environmental strategies and interpret corporate responses to external factors and regulatory requirements (Dragomir et al., 2023). Environmental strategies typically involve setting CO_2 and energy targets in order to reduce their emissions and in turn improving the carbon performance. Such strategies signal that the firms are capable of proactively addressing and efficiently managing their environmental liabilities (Benkraiem et al., 2022; Dragomir et al., 2023). Carbon emission reduction targets generate accountability among companies, which has become increasingly relevant for investors (Dragomir et al., 2023). Therefore, a good carbon performance is often interpreted by the capital market as an indicator of a future-oriented strategy and efficient management of the companies, which may create a competitive advantage for companies (Matsumura et al., 2014).

Furthermore, the disclosure of emissions is usually rewarded by the market, as the resulting transparency reduces investor uncertainty (Matsumura et al., 2014). For instance (Albertini, 2013) investigates a positive relationship between the disclosure of environmental data and the financial performance of a company. Investors can thus better assess regulatory and natural risks, which consequently leads to a better financial performance and lower cost of capital (Hahn et al., 2015). The disclosure of a company's carbon emissions is also often perceived by investors as a positive signal that increases demand (Asyifa & Burhany, 2022; Basse Mama & Mandaroux, 2022). According to (Bolton & Kacperczyk, 2025), disclosure of emissions reduces stock volatility by reducing investor uncertainty. However, it is not only disclosure that is important, but also the actual carbon performance of companies. For instance (Matsumura et al., 2014) found that, on average, each "additional thousands metric tons of carbon emissions" declines the company value by $212,000, which was investigated based on a sample of S&P 500 companies. Furthermore, companies are penalized by the stock market if they have an increased emission level. This is because rising emissions signal future environmental liabilities that lead to higher expenditures, which can trigger a decline in stock prices (Benkraiem et al., 2022; Choi & Luo, 2021). The study by (Houqe et al., 2022) also shows that companies are penalized for higher carbon emissions in the market and therefore have lower financial performance. (Basse Mama & Mandaroux, 2022) also notes that company value declines sharply when carbon emissions exceed a certain threshold, as this leads to high uncertainty about future risks. These negative impacts tend to be more present in countries that publish and enforce strict environmental regulations (Choi & Luo, 2021). This clearly shows that low carbon emissions correlate with a company's financial performance and have a positive impact on the company's value (Makan & Kabra, 2021). Furthermore, the study by (Choi & Luo, 2021) examined the reduction of carbon emissions and how this affects company value. These evidences mentioned above clearly shows the development of the redistribution. High carbon emissions are seen by investors as an indicator of future costs and risks that could negatively impact firms value.

The reduction of carbon emissions and its disclosure indicates proactive management, which creates transparency for investors and minimizes the risk of future costs (Choi & Luo, 2021). This serves as the basis for the first hypothesis:

H1: A better carbon performance is positively related to firm value

2.3 Carbon performance, firm valuation and Corporate Venture Capital

Climate change is accompanied by growing climate and regulatory requirements for companies. To meet these requirements, corporate venture capital (CVC) can serve as a strategic lever that enables the acquisition of external technologies and capabilities. This approach can strengthen and promote sustainability innovations, decarbonization and the competitiveness of the parent company. As a strategic tool, CVC can thus have a positive impact on environmental performance and reduce GHG emissions (Shuwaikh, 2024). This positive effect arises from the fact that CVC investments give parent companies the opportunity to acquire new technologies and knowledge (Benkraiem et al., 2023). According to (Hegeman & Sørheim, 2021b) CVC primarily serves to promote corporate greening and therefore to increase sustainability. This not only improves environmental performance but can also increase long-term financial success. The study of (Shuwaikh et al., 2025) examined both independently venture capital financed companies and CVC financed companies and found that, based on US companies, IVC companies have better ESG ratings and emit lower amounts of greenhouse gases, but CVC companies pursue the goal of promoting green innovations in order to reduce their emissions in the long-term.

Various studies have already shown that there is a strong positive correlation between CVC Investments and the financial performance of parent companies (Shuwaikh, 2024). A company generally makes a CVC investment in order to achieve the long-term goal of creating value and to strengthen the competitiveness of the investing company (Benkraiem et al., 2023; Shuwaikh, 2024). In their study, (Dushnitsky & Lenox, 2006) examined the influence of CVC investments on Tobin´s Q, which is an indicator of the firm value, and found that there is a positive influence on financial performance. Since CVC often promotes innovation and frequently produces new patents, these are viewed positively by market participants, which reflected in a higher market valuation (Benkraiem et al., 2023). For the companies receiving support, strategic assistance also increases the likelihood of an IPO or acquisition and may also lead to a higher valuation in both cases, which in turn quantifies the added value (Ivanov & Xie, 2010).

In summary, it can be said that CVC activities serve as an important lever for innovation and that competitiveness can be increased through the acquisition of new knowledge. Innovation capabilities can reinforce the positive effect of carbon performance on the firm value (Battisti et al., 2022). This means that parent companies can achieve positive financial results though CVC investments in green innovation, which have a positive impact in the value of the company in the short or long term. The newly acquired resources for improving carbon performance therefore strengthen the financial performance of a parent company and can remedy the weakness of internal innovations, creating a sustainable competitive advantage (S. Ma, 2020). Considering the information presented above, the following hypothesis is proposed:

H2: The positive impact of carbon performance on firm value is enhanced in the presence of corporate venture capital

2.4 Firm valuation and innovation capacity

Innovation is considered as a key driver of long-term corporate success, as it supports firms survival in dynamic competitive environments and contributes significantly to increase their performance and strategic development (Sipos & Ionescu, 2018). Prior studies further identified innovation as the fundamental source for growth and productivity (Alam & Adeyinka, 2021). Accordingly a company´s innovation strategy should be focus on the efficient use of its unique resources while continuously improving and strengthening its innovation capabilities, as this serves as the basis for future performance (Shuwaikh et al., 2023). In recent studies, innovation is often defined in terms of expenditures on research and developments or by the number of patents a company holds, both reflecting firms effort to create a competitive advantage (Alam & Adeyinka, 2021). Investors recognize high levels of R&D activity positively, as it is seen as an indicator of growth potential and future earnings opportunities. At the same time increasing regulatory pressure form government and growing social expectations encourage firms to invest more heavily in environmentally oriented innovation (Shuwaikh et al., 2023; VanderPal, 2015).

Innovation can contribute to firm value through multiple channels, including productivity gains, the development of new products and processes and the mitigation of environmental risk to prevent or reduce environmental damage. In this context, so-called green innovations represent one specific form of innovation that comprise new technologies, processes, and products aimed at reducing the environmental footprint of companies, for example by reducing CO_2 emissions (Y. Ma et al., 2017; Shuwaikh et al., 2023). Empirical evidence suggests that investments in environmentally oriented innovation can create long term value. For instance, (Lee & Min, 2015) shows that green R&D investments by Japanese manufacturing companies between 2001 and 2010 contribute to reduce carbon emissions and are associated with higher firm value, as measured by Tobin's Q. (Shuwaikh et al., 2023) examined 243 companies between 2013 and 2020 and similarly document a positive impact on both environmental and financial performance. In a related study (Y. Ma et al., 2017) analyze 267 Chinese coal mining companies and find that green process innovations do not generate significant short-term effects but produce long-term benefits by improving corporate image, which in turn positively affects firm value.

Accordingly, past studies show that investing in innovations can directly contribute to reducing carbon emissions and improving the environment. Consequently, this influence contributes to improving the company's image, which is reflected positively in the company's value. Based on the theoretical arguments outlined above, the third hypothesis investigates the following relationship:

H3: Higher R&D expenses are positively related to firm value

3. Data and methodology

3.1 Sample selection

To investigate the different hypotheses, this study relies on a panel dataset of publicly listed US companies. The analysis covers the period from 2014 to 2019 and includes 177 firms, resulting in a total of 1,062 firm-year observations. The selected period is primarily determined by data availability, especially regarding emissions-related information, which has become more consistently reported in recent years. In addition, the sample period ends in 2019 to avoid potential shocks caused by the COVID-19 pandemic. To ensure robust estimation and avoid the influence of extreme outliers, all variables were winsorized at the 1^{st} and 99^{th} percentiles.

All data for the variables carbon emissions, CVC activity, and innovation were obtained from the database Refinitiv Workspace. The financial and accounting data used to compute Tobin's Q and the control variables were also obtained from Refinitiv Workspace.

3.2 Variable measurements

3.2.1 Dependent variable

Financial Performance/ Firm Value (Tobin´s Q): The three regressions form the central models of the analysis and use the firm value, measured by using Tobin's Q, as the dependent variable. Tobin's Q is a widely used indicator for firm value and represents the ratio of a firm´s market value to its replacement cost and is calculated as follows:

$$Tobin\acute{}s\ Q = \frac{Company\ Market\ Cap + (Total\ Assets - Common\ Equity)}{Total\ Assets}$$

All variables used in the calculation are collected on an annual basis and are reported in US dollars.

3.2.2 Independent variables

Carbon Performance (CarbonRatio): In order to indicate the independent variable CarbonRatio, data for Scope 1 and Scope 2 were collected in the first step. Therefor Scope 1 covers a company´s direct CO_2 and CO_2 equivalent emissions, i.e. those emission that originate from sources owned or directly controlled by the company. In addition to carbon dioxide (CO_2), the greenhouse gas considered in emissions also include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorinated compound (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The CO_2 and CO_2 equivalent emissions mentioned above are also included in Scope 2, although Scope 2 covers indirect emissions resulting from the consumption of purchased electricity, heat or steam and emitted at the point of energy generation. Scope 1 and Scope 2 emission are measured in tons and classified according to the GHG Protocol. Both types of emissions are a central component of companies CO_2 responsibility and its management (Benkraiem et al., 2022). In the second step, the annual revenue of the companies was obtained to determine the variable CarbonRatio, which serves as a measure of the carbon performance. Accordingly, the metric represents the ratio of the sum of Scope 1 and Scope 2 multiplied by one million to the revenue. Multiplying GHG emissions by one million serves to align the order of magnitude with that of revenue, thereby ensuring a consistent ratio for calculating carbon performance. In the end, this ratio is multiplied by (-1), meaning that higher values indicate a better performance, thereby ensuring a consistent and intuitive interpretation of the regression results.

Moderator variable: To examine whether the effect of carbon performance on firm value is reinforced or weakened by other corporate strategic characteristics, this study incorporates CVC as a moderating dummy variable. The CVC variable is modeled using a three-year lag (t-3) to capture the delayed impact of venture investments on firm-level outcomes. This specification follows the study of (Belderbos et al., 2018) which conceptualize firms´ CVC activity as a portfolio of investments accumulated over a prior three-year window and relate firm performance in year (t) to CVC investments undertaken in the preceding years. Their approach is grounded in evidence that the effects of CVC investments on innovation and technological capabilities materialize only with a time lag, reflecting the time required for learning, knowledge transfer and integration processes (Belderbos et al., 2018). Building on this logic, the present study applies a backward-looking CVC specification to capture delayed strategic effects and their potential influence on firm value in year (t). Accordingly, the CVC variable has a value of one if the company has activities either through subsidiaries or via the parent company and zero if there are no activities.

Innovation (LnR&D): The variable LnR&D is considered as a second independent variable and serves as a proxy for firm's innovation activity, as R&D investments can signal growth opportunities to the capital market. It is measured by using the natural logarithm of firms Research and development (R&D) expenses. The logarithmic transformation is applied to mitigate the influence of extreme values and to reduce the skewness in the distribution (Ezhilarasi & Kabra, 2020).

3.2.3 Control variables

This study includes several company-specific characteristics as control variables that are regarded as key drivers of a firm valuation. Company size (Size) is included as the first control variable and is measured as the natural logarithm of total assets. Prior studies documents a relationship between firms size and financial performance (Houqe et al., 2022). In addition, the variable Leverage is included and measured as the ratio of long-term debt to total assets. Debt serves as a proxy for long-term corporate risk (Rokhmawati et al., 2015). Furthermore, the control variable (Capex) is calculated by the ratio of capital expenditures to total assets. Additionally, the variable (Cash) represents the ratio of cash and short-term investments to total assets. (LnROA) was included in the model as an additional variable and corresponds to the natural logarithm of the ratio of net income after minority interests to total assets. Gross domestic product (GDP) is used as a macroeconomic control variable to capture country-specific and cyclical effects. The (ESG) variable was included to account for differences in sustainability quality. It is calculated form the average of the environmental, social and governance pillar scores.

3.3 Model specification

To examine the relationship between carbon performance and firm value, the following regression model is presented for the first hypothesis:

$$\begin{aligned} Tobin\'s\ Q_{it} = {} & \beta_0 + \beta_1 CarbonRatio_{it} + \beta_2 Size_{it} + \beta_3 Leverage_{it} + \beta_4 Capex_{it} \\ & + \beta_5 Cash_{it} + \beta_6 LnROA_{it} + \beta_7 GDP_{it} + \beta_8 ESG_{it} + \Sigma Year_t + \Sigma Firm_i \\ & + \varepsilon_{it} \end{aligned}$$

Tobin's Q measures the firm value of individual companies in individual years, and the variable CarbonRatio refers to carbon performance. This variable is negatively coded and measures emissions in relation to revenue. The control variables are Size, Leverage, Capex, Cash, LnROA, GDP and ESG. Firm and year fixed effects are included to account for unobserved firm-specific heterogeneity and temporal effects.

The second hypothesis examines the moderating effect of CVC on the relationship between carbon performance and firm value. This results in the following regression model for the second hypothesis:

$$\begin{aligned} Tobin\'s\ Q_{it} = {} & \beta_0 + \beta_1 CarbonRatio_{it} + \beta_2 CVC(t-3)_{it} + \beta_3 CarbonRatio_{it} \\ & * CVC(t-3)_{it} + \beta_4 Size_{it} + \beta_5 Leverage_{it} + \beta_6 Capex_{it} + \beta_7 Cash_{it} \\ & + \beta_8 LnROA_{it} + \beta_9 GDP_{it} + \beta_{10} ESG_{it} + \Sigma Year_t + \Sigma Firm_i + \varepsilon_{it} \end{aligned}$$

$CarbonRatio_{it} * CVC(t-3)_{it}$ is the interaction term between the carbon performance variable and the lagged CVC dummy variable measuring the joint effect on firm value. The control variables as well as the firm and year fixed effects are the same as in the first equation.

The third hypothesis examines the relationship between the R&D expenses and the firm value, resulting in the following hypothesis:

$$\begin{aligned} Tobin\'s\ Q_{it} = {} & \beta_0 + \beta_1 LnR\&D_{it} + \beta_2 Size_{it} + \beta_3 Leverage_{it} + \beta_4 Capex_{it} + \beta_5 Cash_{it} \\ & + \beta_6 LnROA_{it} + \beta_7 GDP_{it} + \beta_8 ESG_{it} + \Sigma Year_t + \Sigma Firm_i + \varepsilon_{it} \end{aligned}$$

The variable LnR&D represents the natural logarithm of R&D expenses. The control variables and the firm and year fixed effects are also the same as in the first hypothesis.

All hypotheses are tested using linear panel regression models at the firm-year level. The different specifications include firm fixed effects to control for time-invariant unobserved firm-specific heterogeneity and year fixed effects to account for common macroeconomic shocks and time-specific influences. Standard errors are clustered at the firm level to account for heteroskedasticity and serial correlation within firms over time.

4. Empirical results and discussion

4.1 Descriptive statistics and correlation

Before testing the hypotheses, table 1 provides an overview of the descriptive statistics for the main variables included in this study. Tobin´s Q, used as a proxy for firm value has a mean of 2.197 and a median of 1.769. In addition, the distribution of Tobin´s Q is right-skewed, as indicated by a skewness of 1.993 and a kurtosis of 7.691 can be observed. The explanatory variable CarbonRatio, which indicates that a better carbon performance is reflected by higher (less negative) values, has a negative mean of -354.361 and a negative median of -49.230. The distribution of CarbonRatio is characterized by a negative skewness of -3.853 and a high positive kurtosis of 17.759, indicating that the distribution is different form a normal distribution. The CVC (t-3) dummy variable has a mean of 0.420 and a median of 0.000. The median of zero indicates that the majority of the observations do not engage in CVC-activities during the observed period. Its skewness and kurtosis amount to 0.323 and 1.104, respectively. The variable innovation (LnR&D) has a mean 20.077 and a median of 20.090. Within the sample, the distribution of LnR&D is approximately symmetric, as reflected by a skewness of 0.043 and a kurtosis of 2.107. Furthermore, the financial control variables Size, Leverage, Capex, Cash and LnROA show a mean value of 23.792, 0.283, 0.045, 0.113 and -2.915 respectively and a median of 23.744, 0.280, 0.038, 0.073 and -2.782. Accordingly, the ESG score is at a higher level, with a mean of 67.043 and a median of 68.420. The macroeconomic control variable GDP shows a mean of 2.550 and median of 2.554.

[Insert table 1 here]

Table 2 presents the correlation matrix for the main variables in the model. The positive and statistically significant correlation between CarbonRatio and Tobin's Q of 0.232 initially suggests a positive relationship between carbon performance and firm value. In contrast the dummy variable CVC (t-3) shows no significant correlation with Tobin´s Q, suggesting that CVC activities are not directly related to the firm value. However, CVC is positively and significantly correlated with LnR&D (0.419), indicating that firms with CVC activities have higher R&D expenses. The strongest correlation in the table occurs between the control variable Size and LnR&D (0.726), suggesting that larger companies in the data sample tend to have higher expenditures for innovation. Otherwise, the control variable Size has a negative and statistically significant correlation with Tobin´s Q and CarbonRatio of -0.164 and -0.068 and a statistically significant positive correlation with CVC (t-3) of 0.180. The control variable Leverage is negatively related to CarbonRatio at a 5% significance level with correlations of -0.077. On the other hand, the macroeconomic control variable GDP shows a statistically significant but weak negative correlation with Cash (-0.052) at the 10% significance level. The variable ESG shows the highest correlation with the control variable size (0.287) at a 1% significance level.

[Insert table 2 here]

4.2 Regression analyses

The results of the first hypothesis are presented in table 3 and examine the relationship between the carbon performance and the firm value. The regression output indicates a statistically significant negative coefficient for the CarbonRatio at the 1% level. This implies that, a one-unit increase in the CarbonRatio, which reflects a better carbon performance, indicates a decline of 0.02 percentage points in Tobin's Q, on average.

This result contrasts with the findings of (Benkraiem et al., 2022), which demonstrate, based on a sample of the world's 100 most sustainable companies, that a better carbon performance has a significantly positive effect on Tobin's Q and is therefore rewarded by the capital market. However, the negative relationship between the carbon performance and the firm value are against expectations and do not support the win-win approach, which states that efforts to reduce carbon emissions improve a company's competitiveness and thus its financial performance (Boiral et al., 2012b). Instead, the findings of this study are more consistent with the win-lose approach, which implies that companies' efforts to reduce carbon emissions incur costs that in turn impair competitiveness and thus the financial performance of the company (Boiral et al., 2012b). Nevertheless, the unexpected negative relationship is also consistent with the results of (Adu et al., 2023). This study examines the relationship between carbon performance, CEO compensation, executive compensation, financial performance and market value of non-financial companies in the UK FTSE 350 Index over a ten-year period. The results also indicate a negative relationship between carbon performance and firms´ financial performance as well as their market value.

Regarding the control variables, Size is negatively and statistically significant related to Tobin´s Q (-0.6978) at the 1% significance level, suggesting that larger firms tend to have, on average, a lower Tobin´s Q related to smaller firms, indicating that smaller companies are highly valued. The control variable Capex is significant at the 5% significance level with a Coefficient of 4.9381, meaning that higher investments are associated with a higher Tobin's Q and supporting the conclusion that the market rewards investment. The variable Cash shows a significant negative correlation at the 1% significance level with a coefficient of -1.2232, indicating that too much liquidity is perceived as an inefficient capital allocation. LnROA and GDP, show positive and statistically significant relationships with Tobin´s Q at the 1% significant level with the coefficients of 0.1336 and 7.8827, suggesting that more profitable companies tend to be valued more highly by the market, especially in periods characterized by favorable economic conditions. The market thus reacts to the macroeconomic environment. The ESG score exhibit a negative and statistically significant relationship with Tobin's Q (-0.0084) at the 5% significance level, showing that higher ESG scores are not associated with higher market valuations in the regarding sample period.

In summary, the regression results of the first regression show that in the US sample, better carbon performance is associated with a lower firm value, which initially seems to support the win-lose logic in the short term. The findings also show that the capital market rewards profitability, investments, and the overall economic situation, while a better carbon performance, large cash reserves and high ESG scores tend to be penalized.

[Insert table 3 here]

Table 4 shows the moderating effect of CVC on the relationship between carbon performance and firm value. The CVC dummy variable exhibits a negative and statistically significant relationship with Tobin's Q at the 10% significance level. The coefficient amounts to -0.4753 and therefore indicates that companies with CVC activities form three years ago tend to have a lower valuation today, than comparable firms without CVC activities. Since CVC activities often need time to establish themselves within a company, the three-year trailing period was used. The regression output also indicates a statistically significant negative coefficient for the

CarbonRatio (-0.0014) at the 10% level. The regression results indicate both that carbon performance, measured by the CarbonRatio and CVC activity are individually associated with lower firm value, as reflected by their negative and statistically significant coefficients. However, the focus of Hypotheses 2 is on the interaction term CarbonRatio * CVC (t-3), which captures whether CVC activities moderate the relationship between carbon performance and firm value. The coefficient of the interaction term is negative and statistically significant at the 1% significance level and amounts to -0.22 percentage points.

This is against the initial expectation that the relationship between carbon performance and firm value would be better for firms engaging in CVC activities compared to firms without such activities. Instead, the findings suggest that CVC activities do not promote the positive relationship but rather amplifies the negative valuation effect associated with carbon performance. These findings are consistent with the evidence provided by (Benson & Ziedonis, 2010) who documents that CVC investments do not necessarily enhance firm value and may, in the presence of overconfidence and agency problems, even lead to value destruction. The negative relationship of CVC activities is also examined in the study of (Jeon & Maula, 2022). They investigated that CVC activities are characterized by inherent tensions which, if inadequately managed, may lead to organizational frictions, conflicts and even failures, ultimately exerting a negative impact on firm value. This tension arises from the trade-off between long-term investments and short-term profitability of the core business. Pressure from external stakeholders to achieve favorable short-term performance may cause management to remain focused on core activities, leading CVC activities to be perceived as costly and risky non-core activities. As a result, these tensions may ultimately contribute to a reduction in firm value. In addition, CVC activities may entail risks of opportunistic behavior due to the privileged access to the parent firm´s resources, which can further reduce their value contribution.

The control variable Size continues to show a negative and statistically significant effect on Tobin´s Q (-0.8767) at the 5% level, indicating that smaller companies tend to be valued higher relative to larger firms. Capex shows a positive and statistically significant coefficient (16.5747) at the 5% level, suggesting that higher Investment intensity have a value-enhancing effect, while Leverage, Cash, profitability measured by LnROA and ESG do not display statistically significant effects. Furthermore, macroeconomic conditions, proxied by GDP, are positively and statistically significantly related to Tobin´s Q (3.7918) at the 5% level, highlighting the sensitivity of companies to the macroeconomic environment.

[Insert table 4 here]

Table 5 reports the regression results examining the effect of R&D activities on firm value, measured by Tobin´s Q. Therefore, the coefficient LnR&D is positively and statistically significant at the 1% significance level, implying that one-unit increase in LnR&D indicates an increase of 72.33 percentage points in Tobin´s Q, on average. This finding suggests that firms investing more intensively in research and development are, on average, valued more highly by the capital market, consistent with the view that R&D captures firms' innovation capacity and future growth potential.

These finding are also consistent with the study of (Rahman & Howlader, 2022), which examines 22 pharmaceutical firms in Bangladesh listed on the DSE over the period 2015 to 2019 and found a positive and statistically significant relationship between R&D expenses, firm performance and firm value. Accordingly, the results align with the RBV. The positive impact of R&D expenditures on firm value is further supported by the findings of (VanderPal, 2015), which analyzed 103 companies across various industries between 1979 and 2013 and similarly reports a positive relationship between R&D intensity and firm value.

By investigating the control variables, Size shows a negative and statistically significant relationship with Tobin´s Q (-0.9982) at the 1% significance level, indicating that larger firms tend to have a lower market valuation relative to smaller firms. Leverage is negatively associated with Tobin´s Q (-0.9713) and statistically significant at the 10% significance level, suggesting that higher debt levels may be perceived unfavorably by investors. Both, the variable Cash and ESG indicate a negative and statistically significant association with Tobin´s Q at the 5% level, which may reflect on the cash side concerns related to inefficient cash utilization and on the ESG side, that higher scores are negatively reflected in firm value. The profitability component, measured by LnROA is positively related to the firm value (0.1128) and statistically significant at the 10% level, indicating that higher profitability is rewarded by the market. The macroeconomic variable GDP also shows a positive and statistically significant relation on Tobin´s Q (12.0073) at the 1% significance level, underlining the sensitivity of favorable economic environments.

Overall, the results of the third hypothesis provide strong empirical support for a positive relationship between R&D expenses and the firm value, indicating that innovation-oriented companies are rewarded form the market and increased R&D expenditures tends to be seen as a value-adding investment.

[Insert table 5 here]

4.3 Robustness check

4.3.1 Reverse causality

Columns (1), (2) and (3) of table 6 consider the reverse relationship corresponding to the first hypothesis of this study. Instead of modeling Tobin´s Q as the dependent variable, the CarbonRatio is used as the outcome variable while Tobin´s Q is included as an explanatory variable. This tests whether the firm value acts as a potential driver of firms´ carbon performance.

In column (1), Tobin´s Q exhibits a negative coefficient of -27.4458, which is only weakly significant at the 10% significance level. In column (2) and (3), the model includes Tobin's Q with a one-period (t+1) and a two-period lead (t+2). The estimated effect remains negative but turns statistically insignificant with coefficients of -8.4758 for the one-period lead and -7.4941 for the two-period lead, indicating that the reverse specifications does not provide evidence of strong reverse causality for Hypothesis 1. Instead, the findings support the interpretation, that the negative relationship observed in the main model primarily runs form carbon performance to firm value, while the opposite direction appears to be weakly evident. These findings are consisted with the study of (Vashisht et al., 2025) which found that financial performance does not automatically provide a statistically significant effect on environmental performance in reverse causality analyses.

To test the robustness of the second hypothesis, columns (4), (5) and (6) represent the reverse analysis, which examines whether the firm value, moderated by the effect of CVC activities, influences the carbon performance. Again, the dependent variable remains the CarbonRatio, while Tobin's Q, the lagged dummy variable and the interaction term are represented as explanatory variables. In column (4), the coefficient of Tobin´s Q is -7.4499 and shows a statistically insignificant correlation. The interaction term is also insignificant exhibiting a coefficient of -0.4165. The results in column (5) and (6) with the one-period and a two-period lead also remain unchanged. This means that neither the leaded firm value nor the interaction term reaches the usual common significances levels.

The results reported in columns (4), (5) and (6) indicate that firm value, as well as the interaction term involving CVC (t-3), does not represent a central determinant of carbon performance. It therefore seems plausible to interpret the moderating effect of CVC (t-3), which was identified in the main analysis of hypothesis 2, primarily in its original direction.

Columns (7), (8) and (9) address the reverse causal direction of hypothesis 3. Accordingly, LnR&D is now modeled as the dependent variable, while the firm value forms the central explanatory variable. Therefore, the reverse models investigate whether the firm value itself is a driver of R&D expenses. The model in column (7) shows a clear positive and statistically significant effect at the 1% level. The coefficient of 0.0708 indicate that companies with higher valuations therefore also have a higher R&D intensity. This result remains robust even when Tobin´s Q is included with its one- and two-period leads. Although the coefficient of the leaded Tobin´s Q variables decreases to 0.0638 and 0.0547, it stays statistically significant at the 1% significance level, and is observed in column (8) and (9). (Habtewold, 2023) explicit addresses the problem of the reverse causality between firm value and R&D expenses. It is plausible that companies with better financial performance also have more resources to invest in new R&D activities. Furthermore, a higher market valuation of companies facilitates access to financing and creates more incentives to invest in growth-oriented projects such as R&D (Josheski & Sopova, 2013). The results reported in column (7), (8) and (9) suggest a bidirectional relationship between innovation intensity and firm value, implying that LnR&D cannot be treated as an exogenous variable in the third hypothesis.

In summary, for hypothesis 1 and 2, the models using CarbonRatio as the dependent Variable provide only weak or no evidence of a causal effect of Tobin's Q on carbon performance. There is no dominant causal direction, which suggests that the interpretation of the main results remains robust regarding reverse causality. In contrast, the reverse model to hypothesis 3 shows a clear positive relationship between firm value and the variable LnR&D, suggesting a reciprocal relationship between innovation activities and firm value.

[Insert table 6 here]

4.3.2 Placebo test

Table 7 shows the results of the placebo test. This test was conducted to examine the robustness of the relationships observed in the main analyses. It specifically tests whether the regressions in this study tend to produce relationships for other arbitrary target variables or whether the relationship found are specific to firm value. For the placebo test, the original regressions are retained, where only the dependent variable Tobin´s Q is replaced by the variable Leverage.

There are no theoretical expectations that the CarbonRatio, the interaction with CVC or the expenses in Research and Development (LnR&D) will have a direct impact on Leverage.

Column (1) shows no significant effect. Therefore, there is no indication that the carbon performance of companies is systematically related to debt. The control variables also remain largely insignificant, while only the control variable GDP showing a positive and statistically significant relationship with leverage at the 1% significance level. In summary, this suggests that the model does not generate an artificial effect from the independent variable CarbonRatio.

Column (2) examines the interaction between the CarbonRatio and CVC (t-3). Here, it becomes clear that the CarbonRatio remains insignificant, while the CVC variable shows significance at the 5% level and the interaction term at the 10% level. However, the relationship between carbon performance and firm value, as well as its moderation by CVC, is not transferred to the Leverage variable in the same way, as a positive relationship is observed. Consequently, the effect remains statistically insignificant.

Column (3) examines the relationship between Leverage and LnR&D. Here, the coefficient of LnR&D is also insignificant and thus provides no indication of a relationship between the R&D intensity and the company´s debt during the observation period. Only the control variable GDP shows a strongly significant relationship.

The placebo test provides evidence that the core variables of the main hypotheses do not capture a general effect but rather show effects that are specific to firm value.

[Insert table 7 here]

5. Limitations and future research

Despite the empirical findings, the results of this study are subject to several limitations that must be considered when interpreting the findings and when drawing further conclusions.

This study focuses on the US market and exclusively on publicly listed US companies, thus limiting the generalizability of the results to other countries and their institutional settings. Due to the US specific focus, the results may be influenced by country-specific political and regulatory developments. Climate policy and regulations regarding emissions disclosure are highly contested and can vary across legislative periods. Such changes can directly affect firms cost structures and investment incentives, by influencing both emissions and firm valuations.

As this study does not explicitly model political developments or regulatory shocks, the estimated effects may partially capture unobserved institutional influences. Therefore, future research could incorporate political or regulatory variables or extend the analysis to a different market.

Furthermore, this study relies on Scope 1 and Scope 2 emissions, while Scope 3 emissions are not considered due to limited and inconsistent data availability. However, since Scope 3 emissions also contribute to a company's overall environmental footprint, the environmental impact of individual firms may be underestimated or present not a clear image. Future research could therefore extend the analysis by including Scope 3 emissions as soon as data availability and quality is improved. This would provide a more comprehensive picture of the firms emissions profiles.

Another point to consider is the timeframe of the studies. This study covers the period from 2014 to 2019. However, the relationship between environmental performance, innovation, and firm value is dynamic and can be characterized by a period of adjustments. For example, this period includes the publication of the Paris Agreement in 2015 and ends before the global COVID-19 pandemic. Furthermore, decarbonization efforts often generate long-term benefits while the associated costs for companies are incurred immediate. Therefore, future studies could cover a longer time horizon or use different modeling approaches to better capture the delayed effect.

In summary, the study provides important insights into the relationship between carbon performance, CVC as a moderating factor, innovation and firm value. At the same time, it highlights the complexity of climate policy regulations and the firms' strategic responses to them. Taken together, these limitations therefore offer valuable starting points for future research to further examine the conditions under which sustainability-oriented strategies contribute to long-term corporate value.

6. Conclusion and implications

This study investigates the relationship between carbon performance, CVC as a moderating factor, innovation and firm value. The empirical analysis is based on a panel dataset of 177 publicly listed US companies observed between 2014 and 2019.

The empirical results of the study indicate that improvements in carbon performance are associated with a negative effect on firm value. This finding suggests that, during the observation period, capital markets tended to notice decarbonization efforts as cost-intensive or value-reducing rather than value-enhancing in the short to medium term. Emission reductions are often linked to substantial upfront investments, operational adjustments and regulatory compliance costs. These immediate financial burdens may initially outweigh the potential long-term benefits. Consequently, the results support a differentiated interpretation of the relationship between environmental performance and firm value and highlight that improvements in carbon performance are not automatically translate into a positive market valuation effect. Consistent with resource-based arguments, the findings further suggest that environmental investments may initially place a liability on firm's resources before potential competitive advantages materialize. Environmental performance should therefore not only be interpreted as a strategic resource but also as a potential source of short-term financial pressure.

Furthermore, the analysis concludes that the expected moderating role of CVC activities is limited. Although CVC is often presented as an instrument for increasing innovation and promoting strategic renewal, the findings provide no evidence that CVC activities systematically mitigate the negative valuation effects associated with carbon performance.

The negative relationship between carbon performance, both with and without the interaction term, and firm value can be interpreted within the context of the institutional and regulatory environment during the observed period. The observation window includes the announcement of the United States' withdrawal from the Paris Agreement following the inauguration of President Donald Trump in 2017, which signaled a weakening of federal support for climate policy. Despite regulatory rollbacks, this political shift did not lead to a sustained positive revaluation of publicly listed firms. Capital markets remained focused on long-term transformation pathways and continued to value future climate-related risks. Against this background, it seems plausible that sustainability-oriented measures as well as long-term oriented innovation and CVC activities were primarily associated with short-term costs and increased uncertainty rather than immediate value creation (Diaz-Rainey et al., 2021).

In contrast, the results show a positive relationship between R&D expenses and firm value. This finding underscores that innovation investments are generally rewarded by the capital market, regardless of whether they are directly related to environmental or climate strategies. In summary, the findings indicate that while capital markets between 2014 and 2019 valued innovation activities positively sustainability-related initiatives were not automatically priced as value-enhancing.

Overall, the study highlights that the valuation of sustainability-oriented strategies is highly time- and context-dependent. The results reflect a transitional phase in which climate regulations and sustainability considerations were gaining increasing relevance but had not yet reached the market relevance and regulatory commitment observed today. By offering a differentiated perspective on the relationship between environmental performance, innovation, and firm value, this study demonstrates that sustainable strategies do not fundamentally generate short-term value. Instead, their valuation critically depends on the institutional environment and the considered time horizon.

7. Appendices

Table 1 Descriptive statistics

	Mean	SD	Min	p25	Median	p75	Max	Skewness	Kurtosis
Tobin´s Q	2.197	1.278	0.902	1.332	1.769	2.596	9.193	1.993	7.691
CarbonRatio	-354.361	881.570	-4.8e+03	-217.020	-49.230	-20.275	-1.176	-3.853	17.759
CVC (t-3)	0.420	0.495	0.000	0.000	0.000	1.000	1.000	0.323	1.104
LnR&D	20.077	1.842	15.761	18.698	20.090	21.474	23.982	0.043	2.107
Size	23.792	1.179	21.388	22.984	23.744	24.584	26.654	0.136	2.607
Leverage	0.283	0.138	0.000	0.191	0.280	0.364	0.707	0.385	3.415
Capex	0.045	0.031	0.001	0.023	0.038	0.063	0.162	1.260	4.774
Cash	0.113	0.122	0.001	0.025	0.073	0.148	0.531	1.724	5.670
LnROA	-2.915	0.897	-8.613	-3.440	-2.782	-2.331	-1.258	-1.514	8.445
GDP	2.550	0.382	1.820	2.458	2.554	2.946	2.967	-0.764	2.661
ESG	67.043	13.087	34.309	59.321	68.420	76.728	90.141	-0.489	2.779

This table provides an overview of the descriptive statistics for all variables included in the sample during the period 2014-2019.

Table 2 Correlation Matrix

	Tobin´s Q	CarbonRatio	CVC (t-3)	LnR&D	Size	Leverage	Capex	Cash	LnROA	GDP	ESG
Tobin´s Q	1										
CarbonRatio	0.232***	1									
CVC (t-3)	0.054	-0.060	1								
LnR&D	0.177***	0.248***	0.419***	1							
Size	-0.164***	-0.068**	0.180**	0.726***	1						
Leverage	-0.014	-0.077**	-0.057	-0.171***	-0.022	1					
Capex	-0.173***	-0.352***	0.276***	0.011	0.163***	0.030	1				
Cash	0.425***	0.235***	0.262***	0.458***	-0.024	-0.216***	-0.242***	1			
LnROA	0.547***	0.210***	-0.102	0.122**	-0.084***	-0.070**	-0.099***	0.278***	1		
GDP	-0.014	0.008	-0.032	0.008	0.013	-0.005	0.042	-0.052*	-0.002	1	
ESG	0.000	0.085***	0.113	0.231***	0.287***	0.046	-0.014	-0.036	0.029	0.010	1

This table presents the Pearson correlation matrix for all variables included in the sample during the period 2014-2019. The t-statistics are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% levels.

Table 3 Effects of Carbon Performance and firm value

	Tobin's Q
CarbonRatio	-0.0002***
	(-5.04)
Size	-0.6978***
	(-3.78)
Leverage	-0.2120
	(-0.50)
Capex	4.9381**
	(2.12)
Cash	-1.2232***
	(-2.88)
LnROA	0.1336***
	(3.34)
GDP	7.8827***
	(5.86)
ESG	-0.0084**
	(-2.07)
Constant	-0.3396
	(-0.06)
Firm Fixed Effects	YES
Year Fixed Effects	YES
Adj. R^2	0.203
Observations	956

This table reports results from panel regressions where the relationship between carbon performance and firm value over the period of 2014-2019 was investigated. Firm and year fixed effects are included in all specifications. The t-statistics are reported in parentheses and are based on standard errors clustered at the firm level. ***, **, * indicate significance at the 1%, 5%, and 10% levels.

Table 4 The moderating effect of CVC

	(1) Tobin's Q
CarbonRatio	-0.0014*
	(-2.00)
CVC (t-3)	-0.4753*
	(-1.78)
CarbonRatio * CVC (t-3)	-0.0022***
	(-3.11)
Size	-0.8767**
	(-2.57)
Leverage	1.6963
	(1.24)
Capex	16.5747**
	(2.30)
Cash	-0.2849
	(-0.21)
LnROA	0.0202
	(0.50)
GDP	3.7918**
	(2.34)
ESG	-0.0062
	(-0.61)
Constant	14.5609*
	(1.93)
Firm Fixed Effects	YES
Year Fixed Effects	YES
Adj. R^2	0.322
Observations	116

This table reports the moderating effect of CVC (t-3) on the relationship between carbon performance and firm value. Firm and year fixed effects are included in all specifications. The t-statistics are reported in parentheses and are based on standard errors clustered at the firm level. ***, **, * indicate significance at the 1%, 5%, and 10% levels.

Table 5 The effect of R&D

	(1) Tobin's Q
LnR&D	0.7233***
	(3.61)
Size	-0.9982***
	(-3.79)
Leverage	-0.9713*
	(-1.84)
Capex	8.3353
	(1.24)
Cash	-1.0029**
	(-2.15)
LnROA	0.1128*
	(1.79)
GDP	12.0073***
	(4.74)
ESG	-0.0190**
	(-2.26)
Constant	-17.0856
	(-1.48)
Firm Fixed Effects	YES
Year Fixed Effects	YES
Adj. R^2	0.283
Observations	437

This table reports results from the relationship between innovation capacity and firm value over the period of 2014-2019. Firm and year fixed effects are included in all specifications. The t-statistics are reported in parentheses and are based on standard errors clustered at the firm level. ***, **, * indicate significance at the 1%, 5%, and 10% levels.

Table 6 Reverse causality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		CarbonRatio			CarbonRatio			LnR&D	
	H1 (t)	H1 (t+1)	H1 (t+2)	H2 (t)	H2 (t+1)	H2 (t+2)	H3 (t)	H3 (t+1)	H3 (t+2)
Tobin´s Q	-27.4458*			-7.4499			0.0708***		
	(-1.82)			(-0.94)			(3.41)		
Tobin´s Q (t+1)		-8.4758			-8.4160			0.0638***	
		(-1.53)			(-1.17)			(4.07)	
Tobin´s Q (t+2)			-7.4941			-4.1850			0.0547***
			(-1.28)			(-1.13)			(4.18)
CVC (t-3)				0.2715	1.6963	-0.9566			
				(0.01)	(0.08)	(-0.05)			
Tobin´s Q (t) * CVC (t-3)				-0.4165					
				(-0.10)					
Tobin's Q (t+1) * CVC (t-3)					-0.8020				
					(-0.26)				
Tobin´s Q (t+2) * CVC (t-3)						0.6984			
						(0.24)			
Size	-95.0290	-80.0521	-77.1970	-7.2870	-1.5780	-2.7353	0.4938***	0.4735***	0.4479***
	(-1.27)	(-1.18)	(-1.16)	(-0.29)	(-0.06)	(-0.11)	(5.01)	(4.84)	(4.59)
Leverage	-13.7250	-3.3457	-1.1255	27.0683	22.6803	14.8263	-0.0253	-0.0905	-0.1199
	(-0.26)	(-0.06)	(-0.02)	(0.32)	(0.27)	(0.20)	(-0.13)	(-0.49)	(-0.63)
Capex	290.2679	175.2838	182.3724	959.6734	865.4130	844.3032	2.3251	2.7124*	2.7141*
	(0.68)	(0.40)	(0.42)	(0.91)	(0.89)	(0.85)	(1.48)	(1.86)	(1.94)
Cash	60.3933	78.7500	82.1809	108.7898	101.1920	103.9081	-0.1046	-0.0614	-0.1000
	(0.92)	(1.10)	(1.10)	(0.92)	(0.89)	(0.85)	(-0.52)	(-0.30)	(-0.48)
LnROA	22.1222*	19.0362*	18.9651*	1.0917	0.5454	0.7121	0.0397	0.0472	0.0451
	(1.73)	(1.66)	(1.67)	(0.28)	(0.15)	(0.19)	(1.08)	(1.30)	(1.23)
GDP	1.9e+03*	1.8e+03*	1.8e+03*	176.3195	198.9231	173.1993	-1.0313	-1.1404	-0.9230
	(1.96)	(1.94)	(1.97)	(1.46)	(1.49)	(1.53)	(-0.86)	(-0.93)	(-0.78)
ESG	-3.3664*	-3.1994	-3.1773	-0.5433	-0.6371	-0.5756	0.0099***	0.0099***	0.0095***
	(-1.66)	(-1.62)	(-1.62)	(-1.47)	(-1.54)	(-1.51)	(3.37)	(3.41)	(3.26)
Firm Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Adj. R^2	0.000	0.002	0.002	0.122	0.152	0.105	0.597	0.602	0.597

Observations	956	956	956	116	116	116	437	437	437

This table reports a set of reverse-causality specifications. It presents results of the relationship between carbon performance and firm value, the moderating effect and the relationship between innovation capacity and firm value. Tobin´s Q and its one – and two period lead are included as the explanatory variables. Firm and year fixed effects are included in all specifications. The t-statistics are reported in parentheses and are based on standard errors clustered at the firm level. ***, **, * indicate significance at the 1%, 5%, and 10% levels.

Table 7 Placebo test

	(1)	(2)	(3)
		Leverage	
	H1	H2	H3
CarbonRatio	-0.0000	0.0000	
	(-0.14)	(0.29)	
CVC (t-3)		0.0452**	
		(2.07)	
CarbonRatio * CVC (t-3)		0.0001*	
		(1.74)	
LnR&D			-0.0111
			(-0.48)
Size	0.0149	0.0227	0.0183
	(0.68)	(0.54)	(0.60)
Capex	0.0108	-0.2350	-0.1161
	(0.05)	(-0.35)	(-0.27)
Cash	0.0990	-0.1687	0.1329*
	(1.44)	(-1.18)	(1.79)
LnROA	-0.0039	-0.0015	-0.0051
	(-1.06)	(-0.39)	(-0.83)
GDP	0.7179***	-0.1962*	1.0041***
	(4.39)	(-1.78)	(3.89)
ESG	0.0002	-0.0002	0.0006
	(0.51)	(-0.11)	(0.76)
Constant	-1.9523***	0.2160	-2.5924***
	(-4.00)	(0.24)	(-3.25)
Firm Fixed Effects	YES	YES	YES
Year Fixed Effects	YES	YES	YES
Adj. R^2	0.002	0.038	0.019
Observations	956	116	437

This table presents the placebo test in which Leverage is used as an alternative dependent variable. It shows results of the relationship between carbon performance and leverage, the moderating effect of CVC and the relationship between innovation capacity and leverage. Firm and year fixed effects are included in all specifications. The t-statistics are reported in parentheses and are based on standard errors clustered at the firm level. ***, **, * indicate significance at the 1%, 5%, and 10% levels.

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